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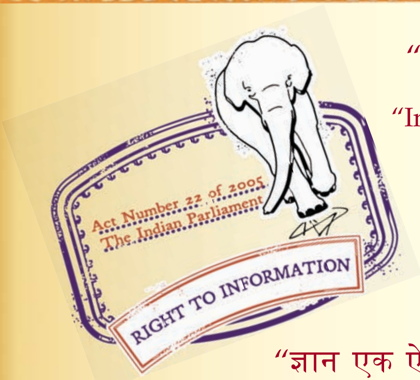

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Indian Standard

DIMENSIONS FOR SPROCKETS FOR 8 mm TYPE S MOTION PICTURE FILM

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 4

June 1984

Indian Standard

DIMENSIONS FOR SPROCKETS FOR 8 mm TYPE S MOTION PICTURE FILM

Cinematographic Equipment Sectional Committee, ETDC 47

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Indian Standard

DIMENSIONS FOR SPROCKETS FOR 8 mm TYPE S MOTION PICTURE FILM

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 28 December 1983, after the draft finalized by the Cinematographic Equipment Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard has been prepared with a view to standardize the dimensions and certain requirements for the design of sprockets for 8 mm Type S motion picture film.

0.3 Additional information regarding sprocket design for the benefit of the user and the manufacturer is included in Appendix A.

0.4 In the preparation of this standard, assistance has been derived from ISO 3820-1978 'Cinematography — Sprockets for 8 mm Type S motion picture film — Dimensions and design' issued by the International Organization for Standardization (ISO).

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard lays down the dimensions and specifies requirements for the design of sprockets used with 8 mm Type S motion picture raw stock or processed film.

*Rules for rounding off numerical values (*revised*).

2. DIMENSIONS AND CHARACTERISTICS

2.1 The teeth shall be equally spaced at an index angle of $360/N$ degrees, where N is the number of teeth. A suitable tolerance for the index angle is $\pm$ 1 minute of arc for sprockets having 12 to 24 teeth and $\pm$ 30 seconds of arc for sprockets having 25 to 84 teeth.

2.2 The root diameter D is computed from the equation:

$$D = N \times \frac{P}{\pi} - T$$

where

P is the perforation pitch,

N is the number of teeth, and

T is the film thickness.

2.3 The minimum value of R_1, as shown in Fig. 1, has been chosen as 3·96 mm. This is an arbitrary choice, but seems appropriate for 8 mm equipment. The shape of the film path as the film leaves the root of the sprocket tooth is determined by film stiffness, set, and tension, as well as by the shape and location of rollers or guides.

For the specified tooth shape, the film has been allowed to slip back over the root circle a distance of 0·046 mm measured at the pitch line (film thickness assumed to be 0·15 mm) by the time the contact point between film and tooth has reached the assumed working height, H, of 0·66 mm (measured radially from the root circle).

This analysis applies to the feed sprocket, for which the sprocket pitch is generally greater than the perforation pitch, and the film must slip in the direction opposite to the direction of motion. The direction of the frictional force between the film and the root surface is such as to assist the feed or the driving action. Of the total 0·046 mm accommodation provided at each tooth for film slippage, approximately 0·013 mm is allocated to the combined tolerance of perforation pitch and sprocket tooth pitch (shorter than average perforation pitch combined with longer than average tooth pitch). An additional 0·008 mm is allocated for, and corresponds approximately to, the distortion resulting from 0·58 N of contact loading. The remaining 0·25 mm corresponds to 0·6 percent of film shrinkage. It should be noted that a combination of 1·16 N of load and approximately 0·4 percent shrinkage with pitch tolerances is about equivalent. By this procedure the values of X_T are determined. As shown in Fig. 3, X_T is the distance measured perpendicular to the radial line intersecting the root of the tooth from a point on the tooth which is 0·66 mm above the root circle.

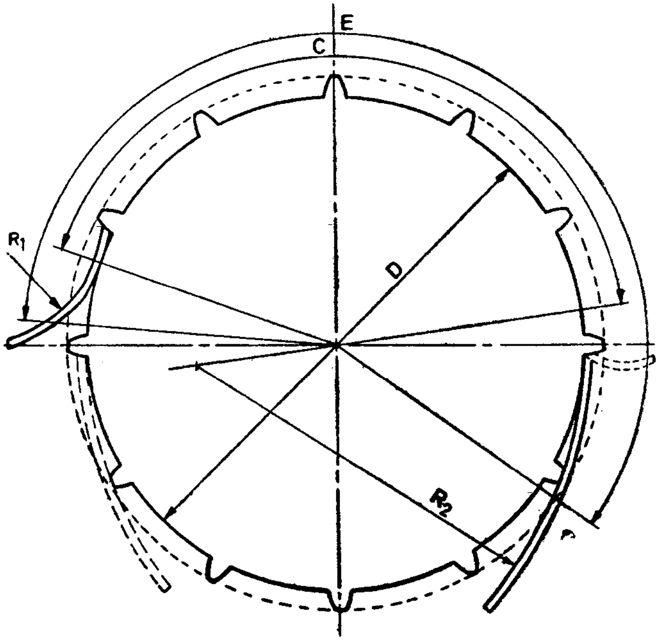


FIG. 1 SPROCKET/FILM RELATIONSHIP

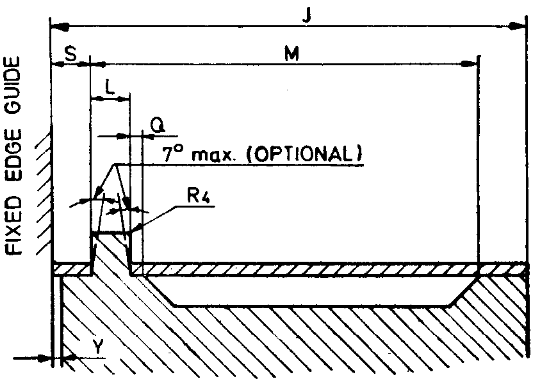


FIG. 2 SPROCKET DRUM PROFILE

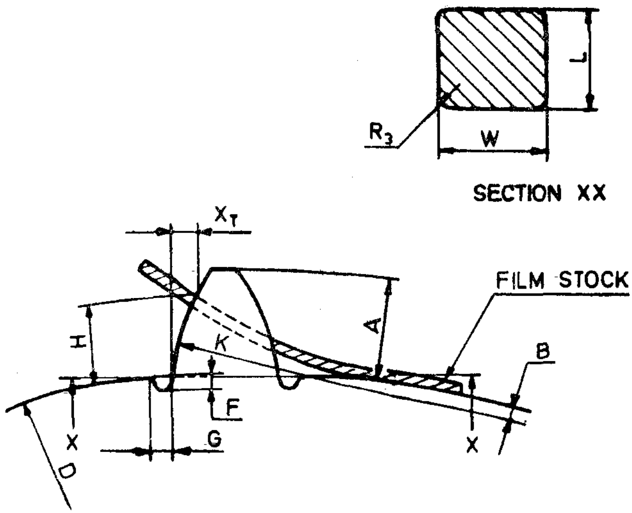
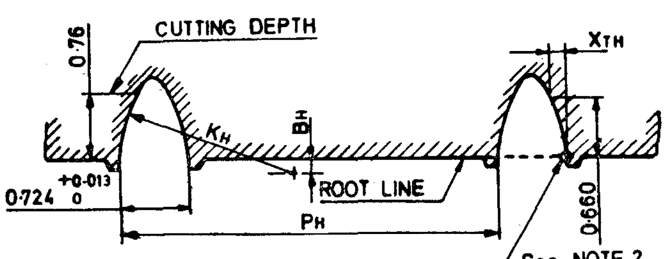


FIG. 3 SPROCKET TOOTH SIDE PROFILE

2.4 The minimum values of R_2 (*see* Fig. 1) have been computed for the same X_T and same accommodation of 0·046 mm assuming a displacement function proportional to the square of time. These values of R_2 shall be as given in Table 1. For the exit film paths corresponding to larger values R_1 or R_2 including a straight tangent path, the accommodation of 0·046 mm for film slippage takes place in less than 0·66 mm of the working height (or more accommodation results at the same height). The accommodation takes place more slowly for the exit path defined by minimum values of R_2; therefore, these are recommended where maximum uniformity of motion is desired.

2.5 The desired tooth shape can be generated by a hob corresponding to the basic rack specified by K_H and B_H as tabulated (*see* Table 3 and Fig. 4). If the first hob covers the range of N from 12 to 24, and the second hob covers the range of N from 25 to 84 no deviations in tooth shape from the ideal greater than 0·003 05 mm will occur.



All dimensions in millimetres.

FIG. 4 BASIC RACK

2.6 The tooth width at the base, dimension W (*see* Table 2 and Fig. 2 and 3) allows ample material for rounding off the tip while preserving the 0·66 mm working height. In some instances some additional height is available. The value chosen does not limit the angle of wrap on the sprocket as a wider tooth would. If the wrap length is defined as one-half of the sum of the number of pitch lengths in the arc of engagement, E, and the number of pitch lengths in the arc of contact, C (Fig. 1), then the wrap length may be as high as $9\frac{1}{2}$ pitch lengths without producing interference at the entering teeth of a drive sprocket if the film shrinkage does not exceed 0·8 percent.

2.7 The lateral profile of the sprocket has been derived on the assumption that the film is channel-guided at or near the sprocket. This guiding may be provided by fixed guides, by the flanges of an adjacent roller at the entering position, or preferably by flanges on the sprocket itself. When a fixed guide is needed at the perforated edge and the film is urged against the guide by a spring or other means, the lateral dimensions L of the tooth can be increased. If the sprocket teeth are to perform the function of side guiding then their laterial dimension L may be increased to

$$0{\cdot}902\,^{\;0}_{-0{\cdot}013}\ \text{mm}$$

with special consideration given to teeth alignment, smoothness of the sides, and rounding or tapering at the tips. When the sprocket teeth have been increased in width to perform the function of lateral guiding, the R_3 value, for the radius of the corners of the sprocket tooth, should be increased to comply with the radius of the perforation fillet, nominally 0·13 mm.

2.8 In order for the film guides to function properly, the sprocket eccentricity as mounted in operation should not exceed 0·025 mm and the lateral weave or wobble measured at the root circle should not exceed 0·025 mm. Less eccentricity may be required for a special application, such as a sound printer sprocket.

2.9 In some cases of large-scale layouts or critical comparisons, it may be more convenient to work with values of X_T than values of B.

TABLE 1 SPROCKET DIMENSIONS

(*Clause* 2.4, and *Fig.* 1)

All dimensions in millimetres.

No. of Teeth, N	D_d	D_c	D_h	K	B	R_2	X_T
12	16·021	15·971	15·895	1·520	0·047	12·584	0·246 0
13	17·363	17·316	17·232	1·574	0·057	13·381	0·240 8
14	18·716	18·658	18·569	1·625	0·067	14·184	0·236 3
15	20·064	20·002	19·906	1·674	0·078	14·988	0·232 4
16	21·412	21·345	21·244	1·722	0·087	15·803	0·228 9
17	22·759	22·689	22·581	1·768	0·097	16·619	0·225 8
18	24·107	24·033	23·918	1·813	0·106	17·431	0·223 1
19	25·455	25·376	25·255	1·856	0·116	18·253	0·220 6
20	26·802	26·720	26·592	1·899	0·124	19·082	0·218 3
21	28·150	28·063	27·930	1·940	0·133	19·903	0·216 3
22	29·498	29·407	29·267	1·981	0.142	20·735	0·214 4
23	30·846	30·750	30·604	2·020	0·151	21·564	0·212 7
24	32·193	32·084	31·941	2·059	0·159	22·400	0·211 1
26	34·889	34·781	34·616	2·135	0·176	24·072	0·208 3
28	37·584	37·468	37·290	2·208	0·192	25·763	0·205 8
30	40·280	40·156	39·965	2·280	0·208	27·453	0·203 7
32	42·975	42·843	42·639	2·349	0·224	29·159	0·201 8
34	45·671	45·530	45·313	2·417	0·239	30·862	0·200 2
36	48·366	48·217	47·988	2·483	0·254	32·585	0·198 7
38	51·062	50·904	50·662	2·549	0·269	34·326	0·197 3
40	53·757	53·591	53·337	2·613	0·283	36·065	0·196 1
42	56·452	56·279	56·011	2·675	0·298	37·798	0·195 1
44	59·148	58·966	58·686	2·737	0·312	39·557	0·194 1
46	61·843	61·653	61·360	2·798	0·326	41·341	0·193 1
48	64·539	64·340	64·035	2·858	0·340	43·112	0·192 2
50	67·234	67·027	66·709	2·918	0·353	44·905	0·191 5
52	69·930	69·714	69·383	2·976	0·367	46·700	0·190 8
54	72·625	72·402	72·058	3·033	0·381	48·494	0·190 2
56	75·321	75·089	74·732	3·091	0·394	50·330	0·189 4
60	80·711	80·463	80·081	3·204	0·420	53·993	0·188 4
64	86·102	85·838	85·430	3·314	0·446	57·707	0·187 4

(*Continued*)

TABLE 1 SPROCKET DIMENSIONS — *Contd*

No. of Teeth, N	D_d	D_c	D_h	K	B	R_2	X_T
68	91·493	91·212	90·779	3·422	0·471	61·439	0·186 6
72	96·884	96·586	96·128	3·528	0·496	65·241	0·185 8
76	102·275	101·961	101·477	3·633	0·521	69·081	0·185 1
80	107·666	107·335	106·826	3·735	0·545	72·955	0·184 5
84	113·057	112·709	112·174	3·837	0·569	76·895	0·183 9

where

N = number of teeth.

D_d = root diameter, $D\,^{+0.03}_{\ \ 0}$ of drive sprocket of 4·234 pitch.

D_c = root diameter, $D\,^{+0.03}_{\ \ 0}$ of combination sprocket of 4·221 pitch.

D_h = root diameter, $D\,^{\ \ 0}_{-0.03}$ of hold-back sprocket of 4·201 pitch.

Film thickness = 0·152.

For other thicknesses:

Root diameter = $N \frac{\text{pitch}}{\pi}$ − thickness.

K = circular arc radius for tooth shape, $^{\ \ 0}_{-0.05}$.

B = radial distance of arc centre inside root circle, $^{+0.013}_{\ \ 0}$.

R_2 = minimum radius of film path concave to sprocket.

X_T = offset of tooth at working height.

Tooth working height, H = 0·660.

Maximum pitch difference = 0·046.

Minimum film path radius convex to sprocket, R_1 = 3·962.

TABLE 2 DIMENSIONS FOR SPROCKET TOOTH AND DRUM

(*Clause* 2.6)

DIMENSION	mm
A	$0{\cdot}71\ ^{+0{\cdot}10}_{\ \ 0}$
B	*See* Table 1
C	*See* 2.6
D	*See* Table 1
E	*See* 2.6
F *Max*	0·10
G *Max*	0·18
H	0·66
K	*See* Table 1
J	$8{\cdot}08\ ^{+0{\cdot}03}_{\ \ 0}$
L	0·61 ± 0·03
M	6·58 ± 0·05
Q *Max*	0·15
R_1	*See* 2.3
R_2	*See* Table 1
R_3 *Max*	0·08
R_4	0·13 ± 0·05
S	0·71 ± 0·03
W	$0{\cdot}71\ ^{+0{\cdot}05}_{\ \ 0}$
Y (where applicable)	Provide clearance

TABLE 3 BASIC RACKS FOR HOBS TO MAKE SPROCKETS

(*Clause* 2.5, and *Fig.* 4)

RANGE OF TEETH, N	PITCH OF RACK, $P_H \pm 0{\cdot}002\,5$ mm	TOOTH SHAPE RADIUS, K_H $^{\ \ 0}_{-0{\cdot}025}$ mm	DISTANCE OF CENTRE BELOW ROOT, B_H $^{+0{\cdot}005}_{\ \ 0}$ mm	REFERENCE DIMENSION — OFFSET AT 0·66 mm HEIGHT, X_{TH}
	mm	mm	mm	mm
12 to 24	4·194	2·028	0·169	0·170 3
25 to 84	4·221	3·371	0·507	0·170 3

NOTE 1 — For some purposes the stated ranges of hobs may be extended in the numbers of teeth specified. However, for more critical uses such as for low flutter or good picture steadiness, the stated ranges should be observed together with suggested film paths.

NOTE 2 — Dimension X_{TH} applies only to the root line of the rack and not to the base.

APPENDIX A

(*Clause* 0.3)

ADDITIONAL INFORMATION ON SPROCKET DESIGN

A-1. It is intended that the pitch of feed sprockets should always be equal to or greater than the pitch of the film. The longest film pitch is assumed to be 4·234 mm corresponding to zero shrinkage with no allowance for plus tolerance during perforating. The pitch of unprocessed film under some conditions of high humidity may be longer. On the other hand, processed film, perforated with the maximum plus tolerance at low humidity conditions, may be shorter by 0·2 or 0·3 percent.

A-1.1 Another condition which gives rise to an effectively longer film pitch is the film distortion at the perforation resulting from higher than normal force at the contact point of the driving tooth. A classical example is the proven benefit to film life if the root diameter of the 16-tooth intermittent sprocket for 35 mm projectors is increased from 24·039 mm (corresponding to unshrunk film) to 24·130 mm. Presumably, the improvement can be explained in part by a better tooth action if the sprocket pitch is equal to or greater than the effective pitch between the loaded perforation and the following perforation which must engage freely. If desired, the designer may exercise control of the pitch by proper selection of the root diameter. The same hobs are usable for the new diameter also.

A-1.2 The friction between the film and root surface of the normal feed sprocket assists in the driving action; however, friction between the film and guide members which control edge position and film path should be minimized.

A-2. It is intended that the pitch of holdback sprockets should be equal to or less than the pitch of the film. The shortest film pitch is assumed to be 4·201 mm, corresponding to 0·8 percent shrinkage of long pitch film 4·234 mm. (This value is chosen rather than the 0·6 percent used for the tooth shape to avoid inadvertent interference at entering teeth.) The user again exercises control by correct choice of the root diameter if he believes that a change is warranted. The friction between the film and the root surface assists in holding back and in addition, the friction against guides also assists.

A-2.1 The tooth shape for a holdback sprocket has little control over the pitch differential accommodation as this occurs rather abruptly near the root of the tooth at the start of disengagement. The tooth shape specified will ensure clearance at the entering position. If a holdback sprocket is to provide good uniformity of motion, in many cases it may be designed as a drive sprocket with an external guide shoe of the minimum R_2 shape to control the entering film path.

A-3. It is intended that the pitch of combination sprockets, 4·221 mm, corresponds to film with 0·3 percent shrinkage. This value is chosen closer to the feed sprocket pitch than to the holdback sprocket pitch to avoid the tendency of the film to ride high on the teeth or to be damaged by guides at the entering path when used for driving action with the sprocket pitch shorter than the film pitch.

A-4. No unique formula has been used to compute the sprocket data. However, there was a logical sequence of computer operations performed in driving the sprocket data, taking practical as well as theoretical considerations into account. The computations were limited to te application of the sprockets as feed sprockets where the tooth must meet shape requirements. Holdback sprockets contact film only near the root diameter and any sprocket tooth designed for feeding will serve equally well for holdback.

A-4.1 The value of R_1 of 3·962 mm or 4·763 mm for 16 mm was chosen as the smallest radius one would expect to use as the path along which the film is guided while leaving the sprocket. This value also results in adequate tooth width at the working height, about 0·3 mm. A larger value of R_1 would result in more flutter and unsteadiness in case of the R_2 path. The driven edges of the film perforations in stripping off the sprocket in the path designated by R_1 must not interfere as they pass the tips of the sprocket teeth. As can be readily appreciated, if the offset of the teeth at the maximum working height is too small, the edges of the perforations would be under load at the tips of the sprocket teeth, and the film would suddenly snap to the position where the next tooth takes up the load, with resultant shock loading and film gouging. The last tooth fully engaged with the film essentially carries the film load. When the film strips off this last tooth, the film slips back relatively to the sprocket base until the next perforation, which is now the last perforation, carries the film load. The maximum slipback of the film (*see* **2.3**) as well as the relative paths taken by the base and tip of the sprocket tooth and by the film were used in the computations of X_T. When X_T is established for each N, the position of one point along the shape of each sprocket tooth relative to the root position has been determined.

A-4.2 It is necessary that the face of each sprocket tooth be as erect as possible to give good load-carrying capacity, and a minimum tendency for the film to ride up on the tooth. Also, of course, the tooth must not force the film to slip along the base of the sprocket in the forward direction at any point as this would increase the load because of friction and would require more total backslip and tooth slant. Yet the tooth shape must provide smooth transfer of the film load from one tooth to the next, at disengagement, for long life of the film. This leads to another requirement that cannot be overlooked in sprocket specifications,

and that is the condition for maximum steadiness of film motion or minimum flutter within the design range of pitch differentials. If the film on exiting from the sprocket is made to ride up the sprocket teeth smoothly, a condition of minimum flutter can be achieved where a smooth transfer of film load from one tooth to the next can be obtained (several teeth are usually engaged simultaneously). The minimum value of the radius (concave toward the sprocket) defiining the existing film path for minimum flutter or maximum smoothness has been designated as R_2 and is listed in Table 1 for each value of N. Computing the value of R_2 would hardly be possible without the electronic computer since a method of successive approximations must be used. The exiting radius R_2 defines the curve of the tooth face. A carefully modified epicycloid best fits this ideal curve. It is far simpler to specify and to use the specifications if the curve of the tooth face is a circular arc with radius and centre given.

A-4.3 On investigation, it was found that errors would be sufficiently small to make the circular arc specification practical. From the data for the tooth face as derived in computing R_2, a point on the face was selected at one-third the working tooth height. Using the position of this point with the established root and tip positions, the radius and its centre were computed for each sprocket. Comparing the positions of points along the sprocket face as defined by the circular arc to those as defined by the ideal curve derived in computing R_2, the maximum deviations at other than the three fixed point were of the order of 0·005 mm.

A-4.4 The arc specification is convenient and lends itself to small quantity production of sprockets with a single formed cutter and indexing means. For larger quantity productions the use of hobs is more economical. Many sprockets have been produced using involute shapes of some specified pressure angle. The slope of the resultant tooth at the root is undesirably reduced and the tooth shape is poorer for steadiness and flutter. The use of the circular arc denotes an important improvement over the use of the involute.

It is anticipated that sprockets not specified by the tables will be specified by interpolation.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2